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Climate change perception and response: Case studies of Fishers from Antigua and Efate

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1. Introduction

The impacts of climate change have been experienced in many countries around the world more so in developing countries although their contribution to this global problem is minimal (Nurse et al., 2014). With limited resources, they lack the required capacity to adequately address the impacts of climate change especially in those Small Island Developing States (SIDS) where the negative impacts have been greatest (Scobie, 2016). Their reliance on natural resources makes them extremely vulnerable in terms of their food security and economic development, especially those located in the Caribbean Sea and the Pacific Ocean (Nurse et al., 2014). These resources have been exploited largely in an unsustainable manner, putting these countries' economies at risk. Their marine resources have been stressed and are now threatened because of overexploitation, habitat degradation and loss, pollution from mainly land-based sources and invasive species (Shelton, 2014). According to the IPCC (2007), climate change poses the most serious threat to the long-term health and survival of these marine resources. In addition to the stresses on marine resources, it has been reported (Dey et al., 2016; Valmonte-Santos et al., 2016) that climate variability and change have also superimposed a number of effects on tropical fisheries in the Caribbean and the South Pacific including sea level rise, increases in ocean temperature and acidity and changes in ocean circulation. These changes are likely to have significant impacts on the marine ecosystems which support socio-economic activities such as tourism and commercial fisheries.

Recent studies have confirmed the predicted impacts on marine resources. With respect to water temperature, Trenberth and Fasullo (2013) and McGregor et al. (2014) found that the world's oceans have continued to warm although there has been an apparent deceleration in surface temperatures. Evidence now exists which confirms an inverse correlation between ocean temperature and fish catches, highlighting the vulnerability of the sector to climate variability and change (Alam et al., 2017). It was reported that during the period 2006–2013, at depths between 0 and 2000 m, warming had ranged between 0.005 °C per year to 0.002 °C, which represents a significant increase (Roemmich et al., 2015).

These warmer surface and sea surface temperatures affect fisheries, not only in terms of habitat health, seen in coral reef bleaching, they affect yields and species composition, distribution and sizes (Sale and Hixon, 2014). Coral bleaching events have been reported in all tropical oceans since the early 1980s, with 1998 and 2005 flagged as the hottest years on record causing the most severe episodes (Spillman et al., 2011). In the Caribbean, for example, the most extensive bleaching event occurred in 2005 which was attributed to above seasonal water temperature by around 1.0–1.5 °C and caused the death of approximately 40% of corals in countries like Antigua & Barbuda (Eakin et al., 2010). Efate's bleaching episodes include 1994, 1998, 2000–2001 and 2010 (Hoegh-Guldberg and Ridgway, 2016). These changes have implications not only for local fishers and the food supply but these episodes significantly disrupt the economic output of these countries so reliant on tourism (van Hooidonk et al., 2015).

As it relates to drought and flooding which sit at opposite ends of the hydrological continuum, both can affect fisheries (Humphries and Baldwin, 2003). There is evidence to show that flooding has major negative impacts on coral reefs as runoff alter the water quality through changes in nutrients, salinity and turbidity which result in a decrease in abundance (Butler et al., 2015). Droughts affect production within the mangrove ecosystem causing hypersaline conditions due to low sediment moisture (Guan et al., 2015). Previous studies report that during drought conditions seedlings, saplings and fauna were absent in addition to no mangrove recruitment (Hoppe-Speer et al., 2013). As mangroves have been linked to 80% of global fish catch, their conservation is key to the survival of this industry (Yessoufou and Stoffberg, 2016).

Studies now report a decline in the growth of corals which is associated with warm ocean temperatures (Sale and Hixon, 2014). Other studies show that there has been a decline in molluscs not only due to the impact of climate variability and change on coral reefs but because of overexploitation (Bao and Drew, 2017). Bunce et al. (2010) (Tanzania and Mozambique) described how fisheries are under pressure from people migrating to coastal areas and taking up artisanal fishing as a means of adaptation, threatening the survival of fishers as yields are decreasing. Invasive species have also increased. Recent studies continue to provide evidence that the Indo-Pacific lion fish (*Pterois volitans*)

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is quickly spreading across the Atlantic. The rapid increase in the Bahamas between 2004 and 2010 coincided with the swift decline in coral reef fishes also causing significant negative impact on the coral reefs themselves (Carballo-Cárdenas, 2015).

The combination of warmer air and ocean temperatures, changes in rainfall, droughts and invasive species has negative impacts on marine ecosystems and fisheries and the communities which rely on these resources (Scavia et al., 2002). This is a major concern for small islands as marine fisheries play an important role in the lives of these people. Marine fisheries contribute to the gross domestic product (GDP) and the food supply, which are linked to other important sectors such as tourism, provide employment and enhances the food security of these countries. In 2014, global captured fish production was 93.4 million tonnes, an increase of 0.8 percent over 2013 (FAO, 2016a,b). In the Caribbean region, in 2012, the fisheries sector's contribution to the GDP ranged from 0.1% to 2.3% (Masters, 2014). In the tropical Pacific, oceanic and coastal fisheries provide many socio-economic benefits to these countries and contribute as much as 25% to their GDP (Bell et al., 2013).

Literature on the extent of the impact of climate change in SIDS is limited, although there has been some improvement (Badjeck et al., 2010; Scobie, 2016). There is still some way to go not only to further knowledge but to find solutions which can be implemented to address food security (Campbell et al., 2016). There are even less studies which assess fishers' perceptions of climate change in small island states. However, there are a number of general fishers' perception studies which provide valuable insights into how they think and may help decision-makers (Tonin and Lucaroni, 2017). These studies cover a number of specific fisheries issues including a study in Tanzania on dynamite fishing activities. Some fishers refused participation in the process to limit this destructive practice because of the perception that they were being ignored by the fishing authorities and had little opportunity to express their opinions on the matter (Katikiro and Mahenge, 2016). A few studies were related to marine biodiversity conservation. For example, in Bangladesh, it was found that their perception of the positive and negative impacts that sanctuaries have on fisheries were influenced by their income, organisation membership, length and motorization of fishing boats (Islam et al., 2016). In another study, the lack of information and participation influenced the fishers' perception of the increasing number of no-take marine reserves. This perception led to distrust of conservation groups and the lack of enthusiasm on the part of fishers (Gelcich et al., 2009). Perception studies were also used as an alternative source of information as was the case in central Chile. Ruano-Chamorro et al. (2017) found that whilst in some instances the fishers' perceptions matched the current and historical data, in other cases the figures were overestimated. It was found that their perceptions were influenced by psychological factors including economic value of target species, fluctuations in revenues and life history patterns.

With regard to comparative studies on fishers' perception of climate variability and change within SIDS, there is no known research which looks at what is happening in the Caribbean and the South Pacific. Comparative climate change studies are not only important as a counterargument to climate scepticism, they provide knowledge on how best to deal with shifting climate change patterns across different regions (Poortinga et al., 2011). This paper aims to start to fill this gap in knowledge and highlight similarities and differences by focusing on the island of Antigua within the Caribbean nation of Antigua & Barbuda and Efate Island within the South Pacific Republic of Vanuatu. It identifies the fishers' perception of climate change, how they matched meteorological data and their adaption strategies.

2. Materials and methods

This work is part of a PhD thesis which looks at climate change threats and responses in SIDS. This paper describes some of the results from one of three livelihoods explored in the research, focusing on perceptions of fishers and their responses to climate variability and change.

2.1. Case study

2.1.1. Antigua

The twin-island nation of Antigua & Barbuda (the third island Redonda is uninhabited) is located in the Leeward Islands and is washed by the Caribbean Sea on the west and the Atlantic Ocean on the east (Fig. 1).[1] According to the *Maritime Areas Act 1982* of the Laws of Antigua and Barbuda, this archipelagic state has an exclusive economic zone of 200 nautical miles (370 km). Antigua & Barbuda has a total shelf area of 3568 km^2 (CRFM, 2013). Antigua is 280 km^2 in size with the highest peak reaching 402 m. Its deeply indented coastline means that it has many beaches and bays which are protected by fringing, large bank reefs and patch reefs. The length of the coastline is approximately 260 km including offshore islands (FAO, 2007). In 2008, the fishing industry contributed about 2% to the GDP. The population of the island in 2013 was 89,985, with the fishing industry providing employment for approximately 1250 (CN, 2016a). The export of fish and fishery products was valued at US$16,837,000 in 2005. Spiny lobster (*Palinuridae*) fisheries dominated the export market in 2005, followed by the queen conch (*Strombus gigas*). Fishers engage in artisanal or small-scale commercial fishing, harvesting mainly (85%) from demersal or reef-based sources (FAO, 2007). The fishing vessels are mainly modern pirogues and launches which are fitted with the most current fishing equipment such as global positioning systems and depth sounders (CN, 2016a). The common fishing gears or practices include traps, handlines and gill nets.

2.1.2. Efate

Vanuatu lies in the South Pacific Ocean, east of north Australia and is made up of approximately 80 islands with 65 inhabited (Fig. 2). This archipelago covers an area of 12,190 km^2 and a water area of 680,000 km^2. Although it has no continental shelf, the length of the coastline is 1920 km. Efate covers an area of 889.5 km^2 with the highest elevation reaching 647 m. It is the main urban centre of Vanuatu and holds the seat of government and has the highest population, approximately 66,000 (GovV, 2009). In addition to the many smaller islands in proximity to Efate, there are mainly fringing reef systems. In 2007, the value of fisheries exports was 62.7 million USD, contributing 1.3% of the GDP. This industry provides employment for approximately 15,000 in the primary sector (CN, 2016b). The focus of this paper is on coastal fishing (reef and lagoon) which is undertaken for subsistence and commercial purposes. Vanuatu also has offshore fisheries which is conducted on an industrial scale, using large foreign-based vessels which focus mainly on the harvesting of tuna (FAO, 2016a,b). Coastal fisheries catch include deep bottom snapper and grouper, using gillnets, handlines, traps and spear-guns (FDA, 2009). The fishing vessels range from the traditional canoes to boats fitted with outboard motors.

2.2. The questionnaire

The structured questionnaire survey was used to interview a random sample of 40 fishermen from each island. The questionnaire was pretested in Antigua on a pilot group of 30 which included 2 fishermen and 5 fisheries officers to enhance the design and content where necessary. A sample size of 30 was used for the main survey as this is established in the literature (Bouma and Ling, 2004). To account for possible non-response, the sample size was increased by 20% (Bryman, 2012). The

[1] Maps throughout this research were created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri® software, please visit www.esri.com."

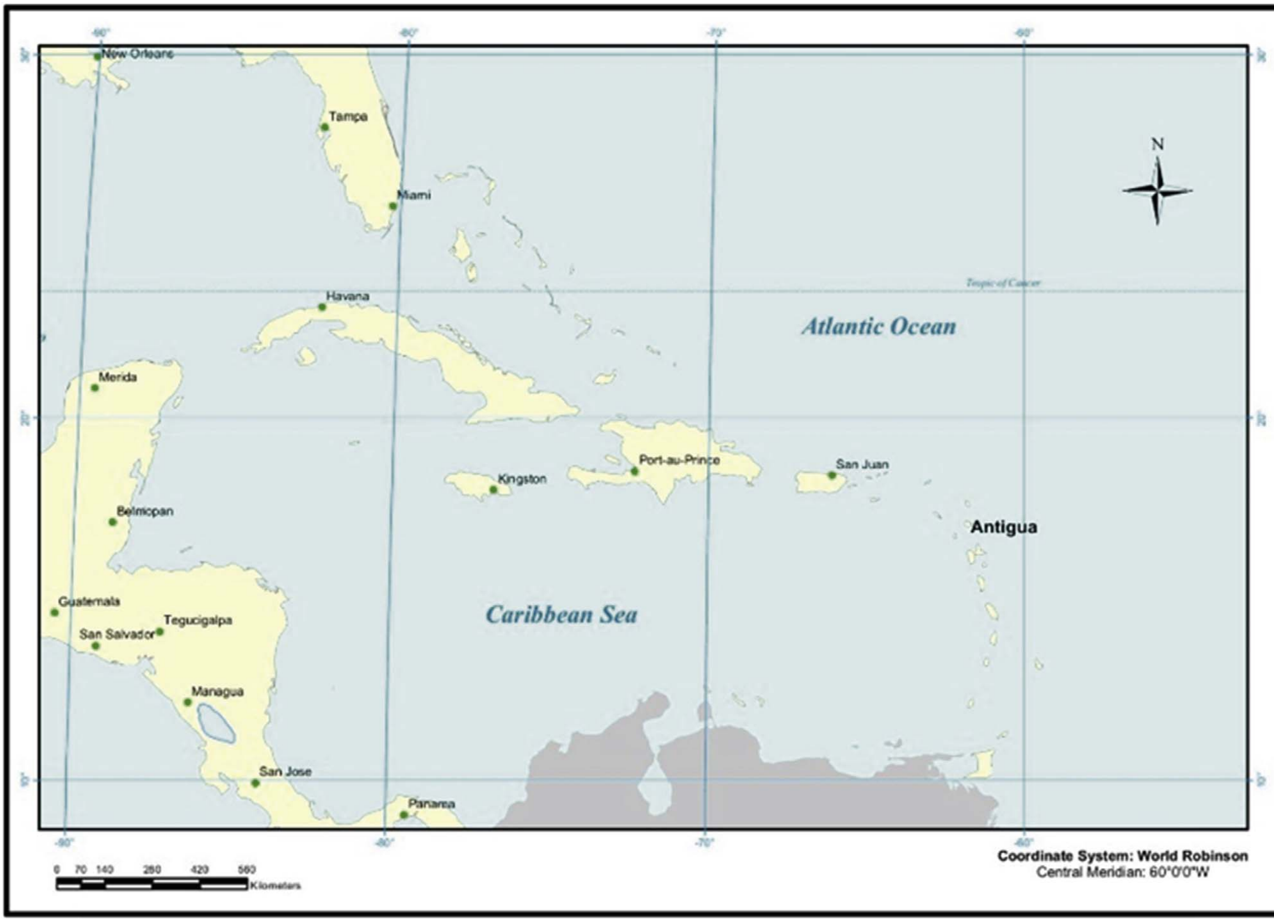

Fig. 1. Location map of Antigua.

40 fishers from each island represent 7.5% and 10.05% of the registered population from Antigua (registered in 2013) and Efate (2009 Census), respectively. Fishers were selected who were registered with the local associations with 10 or more years of experience within the livelihood. In instances where participants did not meet the criteria, a convenience sampling technique was used to obtain the remainder. In this case, 8 of Efate's 40 questionnaires were completed through convenience sampling. These fishers were invited to participate at the landing sites whilst the other interviews were being conducted.

The registered fishers were contacted either via the telephone or face-to-face and the place and time of interviews were established. Most interviews were conducted at the fish landing sites or the fish markets and a small number were conducted in the homes of the fishers. For those interviews conducted in homes, the researcher was accompanied by a fisheries officer. All were given information statements to read and sign before the interviews were conducted, in most cases by the researcher. However, in instances where there were several fishers together especially at landing sites, interviews were also conducted by the researcher's assistant and in others, the questionnaires were self-completed. The questions were in English.

The questionnaire consisted of three parts. Part A addressed the demographic characteristics of the respondents and included questions pertaining to number of fishing vessels owned or leased, fishing methods and employment. Part B looked at the meaning of climate change as well as perception and impacts on the livelihood and how the fishers adapted to the changes they elucidated. In this Part and the next, Likert Scales were used in addition to tick-the-box questions. For the Likert Scale questions, there were five options ranging from strongly agree to strongly disagree. Part C dealt with climate change and the fishing industry, addressing *inter alia* reduction in species, invasive species and catch changes. Changes to the business were also explored as well as the impacts of specific extreme weather events on the operations. This section also looked at future expected impacts and barriers to adaptation. Fishers were also asked about the need for information and training and were invited to give further comment on climate change and their businesses. The time frame varied with the questions and they were easily understood by the respondents. All interviews were conducted during the day. The questionnaires were completed anonymously and took approximately 20 min to complete. The scope of the study was limited to commercial fishers because of the importance of the fishing industry to the economies of small islands.

2.3. Data analysis

Quantitative survey responses were collated by island on spread sheets using Microsoft Excel (2010). The information was then analysed using the SPSS (version 23) to produce summary statistics and frequency tables to compare the socio-demographic characteristics of the participants. Fisher's Exact Test, a non-parametric test, was used to determine statistical significance within frequency tables as well as whether non-random associations were present between data from both islands.

Climate data were collected from the meteorological departments in both Antigua & Barbuda and Vanuatu for the 43 years from 1971 to 2014. The data were analysed using the Mann-Kendall (MK) trend test by means of the Addinsoft XLSTAT 2016.06.36773 for Microsoft Excel. The MK method is used to detect linear trends mainly in rainfall and temperature time series and has been endorsed by the World Meteorological Organisation (WMO, 1988). The MK test is used to determine statistical significance within the data at a p-value = 0.01. The

Fig. 2. Location map of Efate.

MK statistic (S) indicates the existence of a positive or negative trend in the data (ITRC, 2013). In XLSTAT 2016, the MK statistic (S) used for the test and its variance are given by:

$$S = \sum_{i-1}^{x-1} \sum_{j-i+1}^{x} Sgn(x_j - x_i) \tag{1}$$

$$Var\left(S = \frac{n(n-1)(2n+5)}{18}\right) \tag{2}$$

in which n represents the number of observations and x_i ($i = 1 \ldots n$) are the independent observations.

The Sen's slope estimator tells the magnitude of the slope in the trend (Dhanya and Ramachandran, 2016). Based on Jain and Kumar (2012), the slopes (T_i) of all data pairs are first obtained using

$$T_i = \frac{x_j - x_k}{j - k} \quad \text{for } i{=}1, 2, \ldots, N, \tag{3}$$

in which x_j and x_k are data values at time j and k ($j > k$) respectively. The median of these N values of T_i is Sen's estimator of slope which is calculated as

$$\beta = \begin{Bmatrix} T_{\frac{N+1}{2}} & N \text{ is odd} \\ \frac{1}{2}\left(T_{\frac{N}{2}}\right) & N \text{ is even} \end{Bmatrix} \tag{4}$$

A positive β indicates an upward or increasing trend while a negative result indicates a downward or decreasing trend in the data (Dhanya and Ramachandran, 2016; Jain and Kumar, 2012). Both methods have now been used extensively to identify positive or negative trends in meteorological data as well as the resulting statistical significance determined by a p-value < 0.05 (Musinguzi et al., 2016).

Qualitative responses were organized and coded into themes based on the issues highlighted and their frequencies. Themes that emerged were concerns over the imposition of closed season bans, larceny and the need for more information on climate change.

3. Results

3.1. Fishers' characteristics

There were 40 respondents from each island. Most of the fishers were males and over 60% from both islands were between the ages of 35–74 years. Sixty percent of the Antiguan fishers were single with an average of 5 financial dependants. Seventy-eight percent of Efate's fishers were married with the same number of financial dependants as the Antiguans. Most of the fishers had completed primary school and approximately 8% of Efate's fishers had no formal education. The highest percentage of respondents fell within the category that received below US$200 in weekly income. Whilst 60% of Antigua's fishers made between US$200–799 per week, 20% of those from Efate made between US$200–999. Most of the fishers from both islands identified angling as their specialty. The average number of years spent in fishing was 25 and 14 for Antigua and Efate, respectively. Both islands had respondents who had been in the livelihood for 50 years. The demographic characteristics of the fishers are shown in Table 1.

3.2. Fishers' awareness and perception of climate change

Respondents were asked to indicate their levels of agreement or disagreement with statements regarding how they perceived climate

Table 1
Fishers' demographic characteristics.

Factors		Antigua	Efate
Gender (%)	Male	100	97.5
	Female	0	2.5
Age Range (%)	18–24	0	5
	25–34	10	22.5
	35–44	27.5	35
	45–54	30	27.5
	55–64	15	7.5
	65–74	17.5	2.5
	75+	0	0
Number of Financial Dependants		Range from 1 to 9 Mean 5 Mode 2	Range from 2 to 8 Mean 5 Mode 3
Level of Education (%)	Primary	50	82.5
	Secondary	30	7.5
	Technical/ Vocational	5	0
	College	12.5	2.5
	University	2.5	0
	No Formal Education	0	7.5
Weekly Income Range (in US$) (%)	1–199	40	80
	200–299	27.5	2.5
	300–399	15	0
	400–599	7.5	1.0
	600–799	10	5
	800–999	0	2.5
	1000–1249	0	0
	1250–1499	0	0
	1500–1999	0	0
	2000+	0	0
Number of years as a Fisher		Ranged from 10 to 50 Median 25 Mode 10	Ranged from 4 to 50 Median 14 Mode 10
Specialty (%)	Trapping	33	0
	Angling	43	39
	Netting	6	8
	Gathering	10	51
	Spearing	8	2

Table 2
Perceived changes in the climate.

Perceived Changes	Agreed (%)		Disagreed (%)		Neutral (%)	
	Antigua	Efate	Antigua	Efate	Antigua	Efate
Freshwater shortages	84	65	6	19	10	16
Higher temperatures	89	87	3	0	8	13
Higher water temperatures	82	77	5	0	13	23
Increased flooding	34	81	50	6	16	13
Increased hurricanes/ cyclones	76	55	11	26	13	19
Increased rainfall	29	77	55	7	16	16
More frequent droughts	87	74	5	16	8	10
No increase in heat extremes	68	16	25	43	7	41
No increase in rainfall intensity	47	16	48	38	5	46
Strange changes in the weather pattern	92	87	0	0	8	13
Stronger winds	84	81	10	3	6	16
Unpredictable rainfall	79	81	11	3	10	16
Warmer summer months	82	77	2	0	16	23

Antigua $n = 38$, Efate $n = 31$.

change was affecting them. The majority of fishers from Antigua and Efate agreed that the climate was changing (Table 2). Most respondents perceived that there were strange changes in the weather pattern, higher temperatures, stronger winds, more frequent droughts, unpredictable rainfall pattern and higher water temperatures. Disagreements with the statements were generally low. For the Antiguans these were related to the lack of precipitation and for Efate, their disagreements suggested a perception of more heat extremes and greater rainfall intensity. Incidentally, Efate's respondents expressed the highest uncertainty about the statement regarding rainfall intensity. These perceived changes may broadly be placed under three categories: temperature, precipitation and wind speed changes, all of which significantly impact fisheries. These three areas will now be addressed to see how the fishers' perceptions matched the meteorological data and to assess the possible impacts on the livelihood.

3.2.1. Perception of increases in temperature

Eighty-nine percent of the Antiguans perceived that temperatures had increased. Meteorological data for the period 1971–2014 show a statistically significant increasing trend ($p = 0.00$) in the minimum temperature but not the maximum (Table 3). For Efate, 87% perceived that temperatures were now higher. A statistically significant trend was found in the maximum temperature only ($p = 0.00$) at the 95% confidence level. However, the nature of the trends in the maximum temperature for Antigua and the minimum temperature for Efate were toward an increase. Therefore, it was not surprising that fishers from both islands, 82% and 77% for Antigua and Efate respectively, perceived an increase in water temperatures as well.

3.2.2. Perception of changes in precipitation

Fifty-five percent of the Antiguans perceived there was a decrease in rainfall and over 78% felt that rainfall was unpredictable or droughts were more frequent. For Efate, over 76% of the fishers perceived that both flooding and rainfall had increased. Rainfall figures for Antigua and Efate (Table 3) for 1972 to 2014 did not corroborate the fishers' perception although there was high inter-annual variability. However, meteorological data for the 50 years from 1964 to 2014 support the Antiguan fishers' perception that droughts were more frequent. These records showed an increase in *moderate* drought episodes which ranged from 4 to 17 months and lasted for 7.8 months on average when compared to the 30-year period between 1933 and 1963 (ABMS, 2017). Efate on the other hand had experienced extremes in rainfall on a number of occasions including a record 157.7 mm which fell within a 24-h period, in October 2014 (Davies, 2014). Further, meteorological data from Vanuatu show that between 1968 and 2010, 94 Tropical Cyclones (TCs) passed within 400 km of Efate, the area of greatest occurrence of these systems (Diamond et al., 2013). In this regard, it is well-known that increased rainfall associated with TCs often cause flash flooding (Xu et al., 2014) so perhaps this could account for the fishers' perceptions since they did not match the meteorological data. With respect to Antigua, meteorological data show that 56 per cent of the 161 TCs that affected the Lesser Antilles between 1851 and 2015, either the centre directly passed over Antigua or it passed within 15–61 nautical miles from the island (ABMS, 2016). The IPCC (2007) predicted an increase in wind intensities in tropical cyclones, causing higher storm surges which not only reduce the number of fishing days but damage fishing gear and boats as reported by 19% of fishers from both islands.

3.2.3. Perception about changes in wind speed

Although over 80% of fishers from both islands perceived that winds were stronger, analysis of the meteorological data did not substantiate these perceptions. For Antigua, the Mann-Kendall (MK) test revealed a statistically significant decrease in wind speed ($p = 0.00$) during the period 1971–2013 (Table 3). With regard to Efate, although not statistically significant, the positive Kendall (S) ($S = 0.040$) showed that the nature of the trend is toward an increase. However, their perceptions may have been influenced by the passage of tropical systems, during which wind speeds are between 18 and 33 $m\,s^{-1}$ for tropical storms and greater than 33 $m\,s^{-1}$ for hurricanes or cyclones

Table 3
Results of trend analyses for selected climatic variables, Antigua and Efate.

Variables	Mann-Kendall Test								Sen's slope Estimator			
	Kendall (S)		Trend Nature		*p*-value		Trend Significance		Magnitude		Trend Nature	
	Antigua	Efate	Antigua	Efate	Antigua	Efate	Antigua	Efate	Antigua	Efate	Antigua	Efate
Annual Rainfall	−39	83	Negative	Positive	0.68[a]	0.38[a]	No	No	−1.403	5.491	Negative	Positive
Maximum Temperature	142	180	Positive	Positive	0.14[a]	0.00[a]	No	Yes	0.007	0.053	Positive	Positive
Minimum Temperature	0.274	76	Positive	Positive	0.01[a]	0.14[a]	Yes	No	0.011	0.025	Positive	Positive
Wind Speed	−268	40	Negative	Positive	0.00[a]	0.40[a]	Yes	No	−0.050	0.000	Negative	Positive

[a] Two-tailed test at significance level: α 0.05.

Table 4
Perceived changes within fisheries.

Statements	Agreed (%)		Disagreed (%)		Neutral (%)	
	Antigua	Efate	Antigua	Efate	Antigua	Efate
Less seasonality	58	32	40	19	2	49
Changes in the distribution patterns	70	46	17	11	13	43
Changes in the reproductive patterns	45	13	40	46	15	41
Changes in species composition	47	30	38	19	15	51
Growth in pelagics	32	24	38	14	30	62
Growth in corals and molluscs have not slowed	37	0	56	54	7	46
Vessel/gear replacement due to storm events	19	19	79	32	2	49
Increase in disease among the catch	15	30	72	19	13	51
Increase in invasive species	98	16	0	27	2	57
Decrease in the catch	88	41	7	5	5	54
Venturing further to increase the catch	80	49	15	0	5	51

Antigua $n = 40$, Efate $n = 37$.

(Webster et al., 2005). In this regard, over 50% of all fishers perceived there had been an increase in these systems.

3.3. Fishers' perception of climate change impacts on fisheries

The fishers were asked what recent changes they had observed within the livelihood. The main perceived changes were: having to travel further to increase the catch, catch decline, distribution pattern changes and a decline in growth of corals and molluscs (Table 4). Despite the high percentage of uncertainty expressed by Efate's fishers regarding an increase in invasive species, just under 100% of the Antiguans perceived that these had increased. The changes perceived by the fishers were not surprising as they have been linked to either warmer sea surface temperatures, flooding or precipitation changes.

The fishers' perceptions of climate change impacts on their industry were largely corroborated by real data. With the exception of China, there has been a global decline in crustaceans and molluscs by ˜233,000 tons since 1989 (Brander, 2007). In that study Brander (2007) also found evidence of a poleward movement of fish and plankton distribution from regions such as the North East Atlantic. During 1951–2008, a strong correlation was found between warmer ocean temperatures and changes in fish reproduction cycles (Asch, 2015). Recent studies reported that decreased thermal tolerance has caused increases in fish diseases and morbidity (Bruneaux et al., 2017; Crozier and Hutchings, 2014). Between 1990 and 2014, the invasive lion fish reduced some fish species by as much as 45% (Ballew et al., 2016). Further, a study found that between 2005 and 2010 the Crown-of-Thorns starfish reduced coral reef coverage by ˜35% (Kayal et al., 2012). Therefore, the reports were not surprising that fishers were spending more time at sea as well as venturing out further by as much as 50 nm to increase their catch which was shown to be declining (Burke, 2017; Monirul Islam et al., 2014; WECAFC, 2002). Although only 19% of fishers from both islands suffered vessel damage due to storms, some reports document such damage done by cyclones in both regions (Monirul Islam et al., 2014; Rezaee et al., 2016; UN, 2009).

3.4. Adaptation Strategies

The fishers from both the Atlantic and the Pacific perceive that their climates have changed. They were asked to indicate which of a set of changes they had made to their businesses in recent times (Fig. 3) (Antigua $n = 40$, Efate $n = 30$).

Eighty-three percent of the Antiguan fishers sought new fishing areas. Over half of them also used better technologies, purchased better equipment and sought education and training. On the other hand, 87% of Efate's fishers mainly invested in non-fishing activities and 53% sought new fishing areas. The measures implemented by the Antiguans suggest loyalty to the livelihood, making serious effort to increase the catch. Most of Efate's fishers, however, employed income diversification methods to cushion the risk associated with reduced catch as seen in their next significant method, seeking of new fishing areas.

4. Discussion

Regardless of whether the fishers were married or single, this livelihood supported their families for the last several years. However, the Antiguans were more educated and had a higher income from fisheries. Regardless of age, years of experience or education, most fishers from both islands perceived that they were being affected by climate change. Empirical evidence supports the perceptions of strange changes in the weather pattern and higher temperatures in both islands and an increase in drought in Antigua. However, the empirical evidence did not match the perception of less and more rainfall for Antigua and Efate, respectively. The meteorological data did not support the Antiguan fishers' perception of increased wind speed but it did for Efate, though not with any statistical significance.

The fact that empirical data did not always support the perception of fishers suggests an information gap and the need for better information-sharing mechanisms within each island. That rainfall had not significantly increase means that the fishers would have been spared some of the negative impacts associated with increased rainfall such as changes to the physical and chemical properties within the marine environment (Ipinjolu et al., 2014). On the other hand, increased rainfall may provide certain long-term benefits to fishers which include increased productivity through the provision of nutrients (Hoguane et al., 2012). As it relates to wind speed, the empirical data suggests that in general, this would not have impacted the number of fishing days of the fishers as there were no significant increases for both islands (Hasan, 2015).

The area of most concern, however, is the increase in temperature with its negative impacts on distribution, composition, abundance of species as well as certain ecosystem functions (Dee et al., 2016). Increase in temperature will place added stress on this livelihood which has been overexploited, thus further reducing yields. Therefore, it was

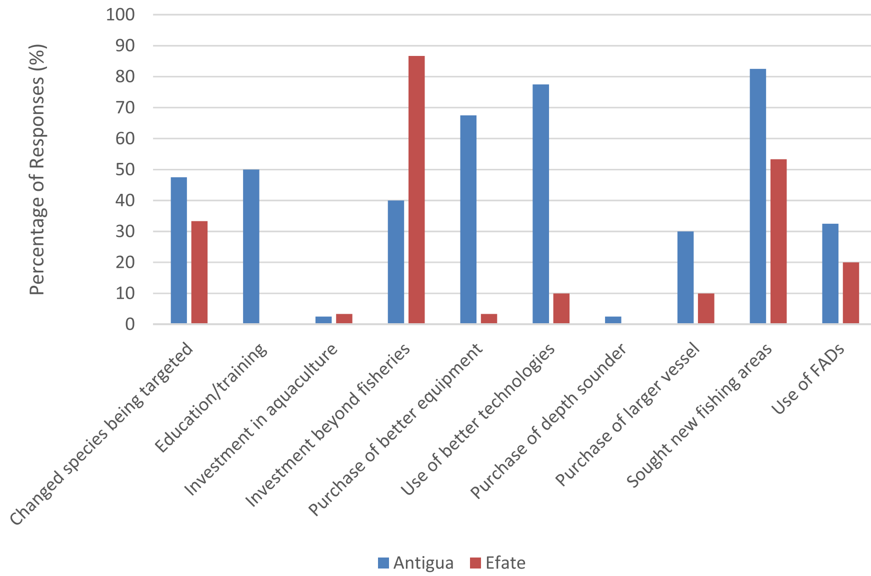

Fig. 3. Adaptation strategies.

not surprising to note that the majority of fishers from both islands agreed that there were changes in the distribution patterns and the catch (decrease) and having to venture further to increase the catch. Further, almost a half of the Antiguans and a third of Efate's fishers also perceived that there were changes in the composition of species. The absence of empirical evidence to corroborate the fishers' perception of these changes does not negate the fact that these changes are occurring. There are enough recent studies to confirm higher water temperatures and the resulting negative impact already mentioned in this study (Alam et al., 2017; Sale and Hixon, 2014). Decreasing yields coupled with having to go further to increase the catch means that the fishers have less disposable income as they have to spend more in fuel for a smaller catch. This further increases the financial strain on the fishers as they have to provide for the needs of their families which, based on their age ranges, would include school-aged children and or infants.

In response to the perceived changes, the fishers from both islands have implemented a number of measures. The measures chosen highlight the differences in the socio-economic situations of the fishers. As more Antiguans received a higher income than their counterparts from Efate, they were in a better position to purchase better equipment and access better technologies.

It must be noted, however, that the measures implemented by the fishers such as having to venture further to increase the catch, were due not only to climate change but to overfishing, hurricanes and stock depletions as well as changes in management practices (reserves or protected areas). The World Ocean Review 2 (2013) found that in the Western Central Atlantic (FAO's region 31 - where Antigua is located) the catch was falling. In the Western Central Pacific (FAO's region 71 and location of Efate), stocks were described as being in a critical condition, fully exploited and over exploited. A recent study found that between 1950 and 2010, global seafood catch declined at a much faster rate than reported by the FAO (Pauly and Zeller, 2016). For areas like the Caribbean, the rate of decline was said to be 60% faster than the official rate (Pala, 2016).

This study heavily relied on the perceptions of fishermen from two different parts of the world. These perceptions have been developed over the years as a result of their experiences and knowledge. As found in previous studies and as noted earlier, these perceptions are influenced by a number of factors including income, knowledge and treatment by those in authority. However, in some cases the fishers' perceptions were corroborated by empirical data and in others it did not. This does not mean that the information obtained is not valid as in Chile (Ruano-Chamorro et al., 2017), the fisher's perception study was used as an alternative source of information. Therefore, the information can be a catalyst for further work with fishers, helping them to develop a better understanding of the observed changes.

5. Conclusion

This research suggests that the climate is changing in the Atlantic and the Pacific. It provides useful information that was heretofore absent on how the fishers from these two islands are addressing climate variability and change. Despite the distance and the differences in socio-economic conditions, the fishers have many similar experiences in terms of climatic change and changes within the industry. It is understandable that fishermen's knowledge cannot be equated to scientific knowledge (Shackeroff et al., 2011). However, in the absence of scientific information, anecdotal evidence plays a pivotal role in establishing the foundation for future ecological studies (Turvey et al., 2010). Similarly, baseline data now exists on the demographic characteristics of the fishers which underscores the importance of the livelihood to the socio-economic development of these small islands and why this livelihood must be supported.

In Antigua and Efate, warmer air and ocean temperatures and changes in precipitation have been the most significant impacts on the sector resulting in more intense tropical systems, droughts, floods and the increase in invasive species. The fishers have responded in ways that match their income and their knowledge. However, in addition to climate variability and change, the sector is affected by other stresses such as overfishing which further compounds the problems. Overfishing itself stems from a number of other issues including the absence of reserves, closed-season bans and immigration.

Therefore, it is imperative for policy makers to implement measures to protect fisheries and build its resilience to these stresses. More support and investment are needed from the government and the private sector to better manage and protect habitats especially through co-management efforts coupled with seasonal bans during periods of low productivity to sustain yields. In this regard, more information and training are required to support the fishers in both Antigua & Barbuda and Vanuatu.

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